

IN THE SPECIFICATION:

Please amend paragraph number [0001] as follows:

[0001] Cross Reference to Related Application: This application is a divisional of application Serial No. 09/146,719, filed September 3, 1998, now U.S. Pat. 6,124,205, issued September 26, 2000.

Please amend paragraph number [0009] as follows:

[0009] The present invention is directed to an improved method for filling contact holes or vias of semiconductor devices and the resulting structures. The improved method begins with insertion of the semiconductor wafer or other substrate of semiconductive material, having one or more contact holes or vias formed in an insulating layer overlying a wafer substrate, into a high-pressure heated chamber. A low-melting point base layer of aluminum material is then deposited over the insulating layer and into the contact holes or vias. During the deposition step, the wafer is heated up to the melting point of the aluminum material to reflow the same into the contact hole or via. Once deposition is completed and while maintaining the ~~temperature elevated,~~ elevated temperature, the chamber is pressurized to force the aluminum material into the contact holes or vias and thus eliminate voids present therein under the aluminum material base layer. A second layer of material, comprising a metal or alloy to be used as a dopant source, is then deposited over a top surface of the deposited aluminum material base layer and allowed to diffuse into the aluminum material base layer in order to form a substantially homogenous aluminum alloy within the contact hole or via. The newly formed homogenous aluminum alloy possesses the desirable characteristics of the previously-mentioned high melting-point aluminum alloys, but without the associated difficulties and disadvantages of depositing such alloys in their preformed state. Formation of the homogenous aluminum alloy within the contact holes or vias of the wafer thus improves the strength, stress migration, and electromagnetic properties of the contacts or vias in a viable, economical manner easily applied to existing fabrication methodologies.

Please amend paragraph number [0023] as follows:

[0023] A principal feature of the sputtering process is that the “target” material is deposited on the substrate 32 over ~~insulating~~ insulation layer 33 without chemical or compositional change, such as seen in the process of chemical vapor deposition (CVD). Deposition of aluminum through sputtering, as opposed to a CVD process, eliminates the need for deposition of TiN, which is required to ensure consistent nucleation of CVD-deposited aluminum prior to such deposition. Another advantage of sputtering over CVD is the conservation of target material composition.

Please amend paragraph number [0026] as follows:

[0026] According to the principles of the present invention, it is possible to thoroughly fill contact hole 37 with a low melting-point aluminum alloy base layer 38, even where contact hole 37 has a high aspect ratio, while maintaining semiconductor substrate 32 at an appreciably low temperature, such as 400°C. This low temperature process advantageously prevents impurities, usually emanating from insulation layer 33, from being taken into aluminum alloy base layer 38, giving aluminum alloy base layer 38 a substantially flat or planar surface which facilitates its working into and alignment with the wirings and surrounding structures. Furthermore, the low temperature process decreases the attendant thermal stress typically seen between substrate 32, ~~insulating~~ insulation layer 33, and aluminum alloy base layer 38 when using high temperature reflow processes.

Please amend paragraph number [0028] as follows:

[0028] As shown in FIG. 4, following the deposition and forced fill steps, a second diffusion layer 40 of metal or alloy is deposited onto an exposed or outer surface 39 of the aluminum alloy base layer 38. Suitable alloys for use as second diffusion layer 40 include alloys of aluminum containing from about 10% to about 60% copper, from about 10% to about 70% silver, greater than about 20% zinc, and greater than about 30% tin. In one preferred embodiment, substantially pure copper is used as the diffusion or dopant source and forms the

second diffusion layer 40. Alternatively, an Al-Cu alloy can be used as a copper diffusion source. Suitable elements for use as a diffusion or dopant source include any metal or alloy which can be made to diffuse into the underlying aluminum alloy base layer 38 and form a homogeneous aluminum alloy having desired electromagnetic and stress migration properties applicable for ULSI devices. Preferred alloys for use as second diffusion layer 40 include alloys of aluminum containing copper, silver, zinc, and tin. Preferred metals for use as second diffusion layer 40 include copper, silver, zinc, tin, and magnesium.

Please amend paragraph number [0029] as follows:

[0029] Where aluminum alloy base layer 38 is selectively deposited over the contact hole 37 areas and not over top surface 36 of insulation layer 33, as previously described in the alternative embodiment, second diffusion layer 40 of metal or alloy is selectively deposited onto exposed or outer surface 39 of the aluminum alloy base layer 38. This selective deposition step can be facilitated through the use of a masking step or any other method known in the art for selective deposition of materials.

Please amend paragraph number [0030] as follows:

[0030] The metals and alloys forming second diffusion layer 40 can be deposited through any suitable deposition technique. One preferred deposition technique involves the deposition of copper by an electroless process. Traditional electroless copper plating processes, wherein an alkaline chelated copper reducing solution deposits a thin copper layer (usually 20 to 100 μ m) on surfaces, can be employed in the instant process. Generally, the electroless plating process is initiated by combining a source of copper, such as copper sulfate (CuSO_4), with a reducing agent (preferably formaldehyde) to reduce the elemental copper (i.e., $\text{Cu}^{+2} = 2\text{e}^- \rightarrow \text{Cu}^0$). Sodium hydroxide is simultaneously combined to maintain the pH between about 11.5 and 12.5 in order to optimize aldehyde reduction. Complexers, such as EDTA and tartrates, hold the copper cations in solution at a high pH. In such a manner, metals such as copper and nickel can be deposited on underlying aluminum alloy base layer 38 to form second diffusion layer 40.

Those skilled in the art will recognize and apply the process steps, specific operating conditions, and process controls required to carry out electroless plating of second diffusion layer 40 according to the principles of this invention.

Please amend paragraph number [0031] as follows:

[0031] Vacuum evaporation is another technique which can be used for the deposition of metals on aluminum alloy base layer 38. Vacuum evaporation takes place inside an evacuated chamber, where a metal is heated to a liquid state so that the atoms or molecules evaporate into the surrounding atmosphere within the chamber. Any known and suitable evaporation method (e.g., filament, electron beam, and flash hot plate evaporation) can be used to evaporate the metals, which will eventually form second diffusion layer 40, in the vacuum system. Vacuum evaporation is preferably performed with pure metals, as alloys are difficult to deposit by this method due to the different evaporation rates at specific temperatures for each element comprising the alloy, which would lead to deposition of second diffusion layer 40 having a different composition than the source alloy material.

Please amend paragraph number [0032] as follows:

[0032] Another preferred deposition technique involves PVD or sputter deposition, as described above with respect to the deposition of aluminum alloy base layer 38. In contrast to the sputter deposition of aluminum alloy base layer 38, the target can comprise any suitable or desirable metal (except aluminum) or alloy which makes an effective diffusion or dopant source (e.g., Cu or AlCu). As previously discussed, various sputtering methods can be used, such as diode sputtering using direct current, diode sputtering using radio frequency, triode sputtering, or magnetron sputtering.

Please amend paragraph number [0033] as follows:

[0033] Sputter deposition is particularly well suited when depositing an alloy as second diffusion layer 40, since sputter deposition does not rely on evaporation of materials having

different evaporation rates. For example, in sputtering, an aluminum and 2% copper target material yields a substantially unchanged aluminum and 2% copper alloy second diffusion layer 40 over aluminum alloy base layer 38.

Please amend paragraph number [0034] as follows:

[0034] As shown in FIG. 5, once the second diffusion layer 40 is deposited onto the aluminum alloy base layer 38, the second layer element(s) diffuse into and form a substantially homogeneous aluminum alloy layer 50. The second layer element(s) 42, constituting the material of the dopant source, is uniformly distributed throughout the aluminum alloy base layer 38 by subjecting wafer 30 to elevated temperatures (preferably 400-500°C), thus forming new alloy layer 50 over ~~insulating-~~ insulation layer 33 and within the contact hole 37. An annealing step can be added to improve dopant distribution and further diffuse the second layer element(s) 42 into the aluminum alloy base layer 38.

Please amend paragraph number [0035] as follows:

[0035] In another preferred embodiment of the present invention, second insulation layer 78 can be deposited on homogeneous aluminum alloy layer 50 to create a multilevel wiring structure 70, as shown in FIG. 6. A third insulation layer 72 can be deposited between the second insulation layer 78 and the homogeneous aluminum alloy layer 50 to provide insulation between wiring structures being formed. Once second insulation layer 78 is deposited, the aforementioned steps (previously described in conjunction with FIGS. 3 through 5) are repeated to form a structure comprising second homogeneous aluminum alloy layer 74 which fills second hole 76 formed within second ~~insulating-~~ insulation layer 78. In carrying out reflow of second homogeneous aluminum alloy layer 74 into second ~~holes-~~ hole 76 formed in the second ~~insulating-~~ insulation layer 78, attention should be directed to avoidance of any disturbance, such as reflow of previously-formed homogeneous aluminum alloy layer 50 of underlying hole 37. Due to the relatively higher melting point of homogeneous aluminum alloy layer 50 as compared to the low melting-point aluminum material initially being deposited within second hole 76, use

of irradiation, either solely or in combination with heating of the second insulating layer by the heater to a temperature slightly above the melting point of the low melting-point aluminum material, is effective in preventing such reflow of existing hole fill materials.